Tests for Iron(II) and Iron(III) Ions

AF 40

Process Objectives

- To design an experiment to determine if an unknown solution contains iron(II) or iron(III) ions.
- To organize the data collected into a chart.

Learning Objectives

- To list compounds useful in identifying the iron(II) and the iron(III) ions.
- To learn how to confirm the presence of the iron(III) ion.

Introduction

In the identification tests for the Fe^{2+} and Fe^{3+} ions we shall use the complex *ferro*cyanide [hexacyanoferrate(II)], $Fe(CN)_6^{4-}$, and *ferri*cyanide [hexacyanoferrate(III)], $Fe(CN)_6^{3-}$, ions. The complex ion charges clearly indicate the difference in the oxidation number of the iron present in the two complexes. The (CN) group in each complex has a charge of 1—. Thus, iron(II) is present in the *ferro*cyanide group, $[Fe^{2+}(CN^-)_6]^{4-}$. Iron(III) is present in the *ferri*cyanide group, $[Fe^{3+}(CN^-)_6]^{3-}$. A deep-blue precipitate results when either complex ion combines with iron in a different oxidation state from that present in the complex. The deep-blue color of the precipitate is caused by the presence of iron in *both* oxidation states. This provides us with the means of identifying either iron ion. If the deep-blue precipitate is formed on addition of the $[Fe^{2+}(CN^-)_6]^{4-}$ complex, the iron ion responsible must be the iron(III) ion. Similarly, a deep-blue precipitate formed with the $[Fe^{3+}(CN^-)_6]^{3-}$ complex indicates the presence of the iron(II) ion.

Both deep-blue precipitates are now recognized as having the same composition. The potassium salts of the complex ions are commonly used, in which case the deep-blue precipitate may be considered to have the composition, $KFeFe(CN)_6 \cdot H_2O$.

The thiocyanate ion, SCN^-, provides an excellent confirming test for the Fe^{3+} ion. The soluble $FeSCN^{2+}$ complex is formed, imparting a rich blood-red color to the solution. Review Chapter 25, Section 25.2, for additional information.The deep-blue precipitate produced in this experiment is found in a number of products. This insoluble $KFeFe(CN)_6 \cdot H_2O$ complex is the "blue" of blueprint paper. It is the pigment in Prussian blue oil paint used by artists for about three hundred years. It is used in inks, carbon paper, and typewriter ribbon. As the main ingredient in certain brands of laundry bluing, it is used to counteract the yellowing of white clothes.

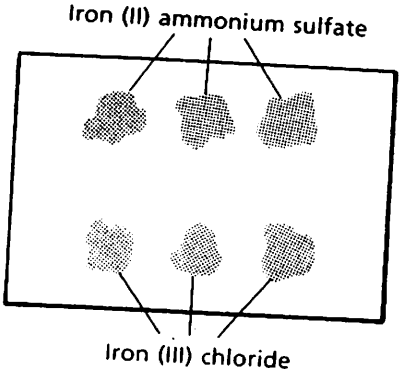
Safety

Take the necessary safety precautions before beginning this experiment. Wear safety goggles, apron, and gloves. As you conduct this experiment, you are required to handle various chemicals. Do not touch the chemicals with your hands. Carefully check the labels on the reagent bottles before removing any of their contents. Observe all safety precautions while conducting experiments. It is important to use good safety techniques while conducting experiments. See pages 8 through 11.

Micro Apparatus

plastic wrap, 8 cm × 30 cm

5 thin stem pipettes



Micro Materials

The following solutions are in the thin stem pipettes.

0.1 *M* iron (III) chloride
0.1 *M* potassium ferricyanide
0.2 *M* iron (II) ammonium sulfate (freshly prepared)
0.2 *M* potassium thiocyanate
0.1 *M* potassium ferrocyanide

Micro Procedures

After completing each procedure record your observations in your Data Table and your notebook.

1. Place the plastic wrap square on a white sheet of paper.
2. Along the top of the plastic wrap place 5 drops of a freshly prepared iron(II) ammonium sulfate solution in each of the locations shown in the diagram.
3. Along the bottom of the plastic wrap place 5 drops of a freshly prepared iron(III) chloride solution in each of the locations shown in the diagram.
4. Add 1 drop of 0.1 *M* $K_4Fe(CN)_6$ solution to the first sample of Iron(II) ions and 1 drop to the first sample of Iron(III) ions. What do you observe?
5. Add 1 drop of 0.1 *M* KSCN solution to the second sample of Iron(II) ions and 1 drop to the second sample of Iron(III) ions. What do you observe?
6. Add 1 drop of 0.1 *M* $K_3Fe(CN)_6$ solution to the third sample of Iron(II) ions and 1 drop to the third sample of Iron(III) ions. What do you observe?
7. After you have completed the questions rinse the plastic wrap with water and discard it in the trash can. Return the thin stem pipettes to the locations specified by your teacher. Wash your hands thoroughly.

Sample Data Table			
	Ferrocyanide ion	Ferricyanide ion	Thiocyanate ion
Iron ion	$[Fe^{2+}(CN^-)_6]^{4-}$	$[Fe^{3+}(CN^-)_6]^{3-}$	SCN^-
Fe^{2+}			
Fe^{3+}			

Questions

Write the answers to these questions in your notebook.

1. State specifically how you would make a conclusive test for an iron(III) salt.
2. Which test for iron(II) ions is conclusive?
3. When the iron(II) ammonium sulfate was mixed with the $[Fe^{2+}(CN^-)_6]^{4-}$ ion, the precipitate was initially white but turned blue upon exposure to air. What happened to the iron(II) ion when the precipitate turned blue?

General Conclusions

1. Suppose you have a solution containing both an iron(II) salt and an iron(III) salt. How would you proceed to identify both Fe^{2+} and Fe^{3+} in this solution?
2. Blueprint paper can be made by soaking paper in a brown solution of $Fe^{3+}(CN^-)_6^{3-}$ and iron(III) ammonium citrate. Wherever the paper is exposed to bright light, the paper turns blue. Explain this phenomenon.

Correlating Your Facts

Complete a copy of the following Data Table on atoms and ions in your notebook.

Sample Data on Atoms and Ions					
	Number of protons	Number of electrons	Net charge	Oxidation number	Symbol
magnesium atom		12	0	0	Mg
magnesium ion	12		+2	+2	
iron atom	26		0	0	Fe
iron (II) ion	26	24	+2	+2	Fe^{2+}
iron (III) ion	26		+3	+3	Fe^{3+}
sodium atom	11	11	0	0	
sodium ion	11	10	+1	+1	Na^+

Complete the following sentences. Place your written answers in your notebook.

1. Any chemical reaction in which an element attains a more positive oxidation state is called _____.
2. The particle whose oxidation state becomes more positive is said to be _____.
3. The oxidation state of an element is represented by a signed number called an _____.
4. The above table indicates that the oxidation number of an atom of a free element is _____.
5. The table also indicates that the oxidation number of a monatomic (one-atomed) ion is equal to its _____.
6. According to the table, the element _____ exhibits more than one oxidation state.
7. Iron is placed with the _____ elements in the Periodic Table.